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ABSTRACT

This study was designed to determine item bias by sex on a test of spatial visualization administered to middle school students. Two chi square techniques were used to assess item bias: the Scheuneman C2 and the Camilli chi square. The direction of bias was indicated by assigning positive signs to the chi square components contributed by one group and negative signs to the other. A computer program to carry out the chi square bias detection techniques was written in FORTRAN 5 to run on a Cyber 750 computer. The program permitted the user to vary the total number of subjects, items, and status groups. The Camilli method usually identified more items as biased than did the Scheuneman method. It tended to place items at a lower probability level. The chi square item bias techniques were shown to have potential for small scale test users and were particularly suitable for mastery and criterion-referenced tests. (DWH)

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A SIMPLIFIED PROGRAM FOR DETECTING ITEM BIAS AND ITS APPLICATION TO A SPATIAL VISUALIZATION TEST

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TM 810 326

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Presented at American Educational Research Association, New Orleans, April 1984

A SIMPLIFIED PROGRAM FOR DETECTING ITEM BIAS AND ITS APPLICATION TO A SPATIAL VISUALIZATION TEST

Introduction

Cultural changes of the last twenty years have produced, among other things, enormous interest in the validity of psychometric testing. One concrete example of this interest is the upsurge in research on bias in testing, including both bias in the test itself and bias in the use of test results. Many new conceptual definitions of bias -- as misprediction, unequal probabilities of success, or invalidity --and workaday techniques for its detection have been developed as the field matures and expands. Educators are also re-examining old assumptions about the distribution of abilities, achievements, and attitudes in school populations. Thus much recent work in test bias is concerned with distinguishing the effects of real bias from the effects of actual differences among groups.

This pilot study looked for individual item bias on a test of spatial visualization administered to several hundred middle school students. The test already had been shown to yield higher total scores for male students than for females. The study intended to determine whether items on the test were indeed biased by sex and whether items identified as biased shared the same factor. The study also compared the results of two chi-square-type indices for detecting item bias, known as the Scheuneman C2 index and the Camilli X^2 index. These techniques are "conditional on ability" (Scheuneman, 1981); that is, they group subjects on the basis of ability as measured by total test score before looking for discrepancies in item performance between status groups. A status group may be based on sex, race, age, ethnicity, handicap, or any other independent population variable. If an item is biased, students of equal ability but different status group membership will have unequal probabilities of answering an item correctly.

Related Research

The literature on sex differences in mathematics is extensive but often contradictory. Studies of sex differences are often weakened by restricted sample selection, measurement errors, and design limitations (Denno, 1982). A widely referenced review of the evidence for sex differences is that of Maccoby and Jacklin (1974). Their analysis of many studies showed that, beginning in early adolescence, males score higher than females on most spatial ability tests, especially those that do not call for verbal mediation (see also Fennema and Sherman, 1977). Spatial abilities have multiple components which are difficult to separate for study; it appears that sex differences may vary across factors (Richmond, 1980). Males also show greater variability in mathematical and spatial scores (Petersen and Wittig, 1979) and are less consistent or predictable over time. Sex differences in spatial ability are larger than those for verbal skill, but the proportion of variance accounted for remains small, generally less than five per cent (Denno, 1982). In short, sex differences in spatial ability seem well established but of uncertain nature, cause, and magnitude.

Evidence regarding statistical sex bias in testing is less common than is research on content validity, language usage, and similar judgmental issues. The test used in this study is mostly visual and makes no sex references of any kind, avoiding a possible source of bias. It does, however, show significant sex differences in total score, making a scrutiny of items worthwhile. Research pertinent to the test itself is reviewed in a dissertation by one of its co-authors (Ben-Haim, 1982). A monograph by Tittle (1978) discusses types of sex bias in testing.

No present item bias statistic possesses all the desirable properties set forth by Ironson (1982). Theoretically, a test bias statistic should have a known sampling distribution to enable significance testing, be powerful and

robust, and be free from artifacts. Psychometrically, it should be reliable and have construct validity (e.g. converge with other techniques, detect planted items). Practically, such a statistic should be easy to calculate and interpret, have wide availability, cost relatively little, and be easy to explain to non-psychometricians. Further, removal of items identified by the technique should not have drastic results for the reliability and validity of the new test.

Several comparative studies (cited in the bibliography and reviewed in Subkoviak et al., 1984) find that the three-parameter item characteristic curve model for detecting item bias appears to be the best on theoretical and psychometric grounds. That technique, however, is expensive, complex, and demands large sample sizes (at least 40 items and 1000 subjects per group), and is thus unsuitable for many applications. The studies usually recommend the chi-square-type techniques as being the best second choice after the three-parameter model. These methods can be used with smaller samples (200 subjects per group), are easier to explain to test users, and can even be calculated by hand if the raw data is in the proper form. The Subkoviak et al. (1984) study found correlations of .88 to .93 of the chi-square techniques with the three-parameter model.

Both chi-square techniques assume that the ability being measured is homogenous and that the total test or subtest score is a reasonable measure of it. They do not require normality of distribution or constant direction of bias, although they can be affected by highly dissimilar distributions, by greatly unequal subjects in the status groups, and by unreliability of the total score.

The Scheuneman C2 (so called because it does not have a true X^2 distribution) was developed independently of latent-trait theory but can be likened to it: "In the chi-square approach, ability is defined by total observed scores and placed into discrete intervals rather than inferred from the item responses and placed on a continuum." (Rudner, 1980a) Scheuneman (1979) suggests visualizing

its probability function as rectangular stair steps, each approximating the height of the item characteristic curve in that ability range. The C2 is computed this way:

$$C2 = \sum_{I=1}^{i} \sum_{J=1}^{j} \frac{(E_{ij} - O_{ij})^2}{E_{ij}}$$

$$df = (I-1)(J-1)$$

I=ability (score) group

J=status group

E=expected value for correct

O=observed value for correct

The second chi-square method, called the Camilli X^2, computes the values for incorrect responses with the same formula and adds it to the C2 value. Its degrees of freedom are found by taking I(J-1).

The Scheuneman C2 is especially useful for mastery tests and in fact was developed for just such a purpose (Scheuneman, 1977). It has been criticized on theoretical grounds by Marascuilo and Slaughter (1981) and Baker (1981) because it cannot be a true chi-square distribution excluding incorrect responses and because it is an omnibus test of differences between expected and observed values, which is less efficient than a series of simple pairwise comparisons. In addition, X^2 values for large samples will be systematically inflated by the status group with the greater number of examinees in an interval when the observed total score distributions are different (Rudner and Convey, 1978). Since the latter effect is systematic, C2 can still be used as an index of relative bias. The Scheuneman statistic, however, can be computed with smaller sample sizes than the Camilli and frequently performs just as well in research studies.

The direction of bias (that is, which status group is favored) can be indicated by assigning positive signs to the chi-square components contributed by one group and negative signs to the other. Signed statistics have a greater range but cannot replace unsigned ones because of the possibility of crossover, e.g. an item that favored low-ability males and high-ability females.

Procedure

The available data bank included 1400 boys and girls in grades 5 through 8. To obtain better homogeneity and control for age (which may affect spatial visualization directly; see Ben-Haim, 1982), only sixth graders were chosen for this study. The sample contained all sixth graders in three middle schools in a midwestern state. School A was located in the inner city section of the state capital and had 40% Black and Latino enrollment. School B was in an upper-middle-class suburb near a large university and was nearly all Caucasian. School C was situated in a very small town surrounded by agricultural land and had a mostly middle-class and white student body. The number of sixth-grade boys and girls was equal at Schools A and C, but School B had more boys (150 vs. 124). The project from which this data was drawn had chosen cluster sampling to facilitate a classroom intervention, for which the classroom was the unit of observation and teacher cooperation was necessary.

The test of spatial visualization analyzed in this study had been developed by several staff members of Michigan State University's Middle Grades Mathematics Project and had been used for other research. It had 32 multiple-choice items with five options each. All options were exclusive (no "all of the above" or "don't know" options) and were intended to reflect possible errors in reasoning. The items were intended to measure ten components of spatial visualization; each factor had from two to six items. The answers were machine-scored for number right. The test was designed to be untimed, and most students finished in 25-30 minutes. The data used in this study was collected in January 1982 during class time by the regular classroom teachers under project staff observation. For the subsample being analyzed in this study, Cronbach alpha reliabilities ranged from .76 to .84. The content validity appeared high, and posttest scores after instruction showed gains. (This study used only pretest scores.)

A computer program to carry out the chi-square bias detection techniques was written in FORTRAN 5 to run on a Cyber 750 computer. The program was designed with the non-statistician user in mind, in hopes that local school districts and test developers might adopt it or use it as a model for screening their own assessment instruments. The program permits the user to vary the total number of subjects, items, and status groups. Because this particular study employed raw data on punched cards, the program incorporates subroutines to key and score the items and to calculate total test score for each subject. It will ultimately be able to set the number of ability levels individually for each item between three and five, five being the optimal choice when cell sizes permit. (The present study used three levels throughout, and the original form of the program reflects that conservative decision.) The program then produces the proportion of correct responses for each status x ability group to an item, calculates both the Scheuneman C2 and the Camilli X^2, and provides significance tests. If small cell size (expected value less than five) makes one or both techniques invalid, the program prints an error message instead of calculating the index.

The treatment of omitted items is an intriguing question but has been little discussed in the literature on item bias techniques. Most research assigns omitted items explicitly or implicitly to the incorrect category. This study distinguishes skipped items from those not reached, scoring the former as incorrect and excluding the latter from analysis in case there is a correlation between sex and omission of items. Excluding skipped or not-reached items means that the Camilli X^2 must be calculated directly from the number of incorrect responses rather than by reciprocal transformation of the correct responses.

Results

For purposes of test construction or revision, it is often helpful to examine items identified at higher levels of significance (.10, .15, or .25) in order to ensure that no component or subarea is unduly troublesome in the number of questionable items. Scheuneman (1975) described how items with negative syntax were eliminated from a version of the Metropolitan Readiness Tests after such an analysis. Accordingly, the computer program used for this study provides a wide range of significance levels.

Of the thirty-two test items, one or both techniques identified three biased items at the .05 level, nine at the .10 level (including the previous three), and fourteen at the .25 level. The full list of items and associated significance levels is found in Table 1. The number of items expected to be identified by the laws of probability would be one or two at the .05 level, three at the .10 level, and eight at the .25 level. Since the number of deviant items actually found is roughly double the expected number, there is a strong suggestion of bias in the test.

The only item detected by both techniques at the .05 level asked students to choose the new object that would result from fitting two three-dimensional objects together. This item was one of the more difficult ones; a similar but easier item was not identified as showing bias.

One of the items detected by both techniques at the .10 level was of average difficulty but inadvertantly included an optical illusion that was discovered by project staff only after the test had been given. The bias was against the female students, who may have been using a suboptimal strategy to arrive at an answer and thus were more susceptible to the effect of the illusion. The other items in the same factor group showed no content bias.

Another possible content bias affected items that involved visualizing two- or three-dimensional arrangements of blocks given their mat plan. The task

resembles reading a blueprint and then imagining the actual appearance of the object; the entire group of items was among the most difficult of tne test. Three of the six items yielded bias scores at .25 or better. The opposite task, working from side views of the object back to the corresponding mat plan, was much easier but also had two of four items biased at the .25 level. The reason for this pattern is not clear; it may indicate differing experiential knowledge for boys and girls or may be related to the high item difficulties.

For "last item reached" the sexes were quite similar: 94% of the boys and 93% of the girls answered the final item on the test, and the number of early quitters was the same. There was a tendency, however, for girls who stopped near the end to do so slightly earlier than boys; 6% of the girls but only 3½% of the boys did not reach item 30. Possibly the finding of bias at the .25 level for items 31 and 32 reflects the effects of speededness or answering at random, as the test items were not ordered by difficulty. Scheuneman (1981) noted that identified items sometimes occur at the end of a test.

The other six items identified as biased at .25 or better by at least one of the techniques seemed to be scattered at random across the ten factor categories and presented no obvious defect. The position of the correct answer among the distractors was unrelated to findings of bias, that is, there was no tendency of one group to consistently select the response offered first, last, etc.

The Camilli method usually identified more items as biased than did the Scheuneman method and tended to place items at a lower probability level, for example, .10 as opposed to .25. The "extra" Camilli items were of average to low difficulty, for which the contribution of the incorrect X^2 values to the statistic would be large; this result is in accordance with the comparative studies cited earlier. The actual items detected by both techniques were largely but not completely in agreement, having ten of the top twelve in common.

Discussion

At the traditional level of .05, the spatial visualization test performed reasonably well, with only one item singled out by both item bias techniques. The larger-than-expected numbers of somewhat biased items ($p < .25$), particularly the cluster in a pair of factors, suggests that some revision of the test may be necessary if it is to be used to compare sexes or to make educational decisions about individual girls. Although the chi-square techniques, like all item bias techniques, cannot detect constant bias throughout the test because of their dependence on the internal criterion of total test score, the findings here imply that most of the test has reasonable validity for both sexes. Girls and boys with equal ability as defined by total test score will usually have similar probabilities of getting a particular item correct.

Since no external criterion for biased items existed, it is difficult to judge how well the chi-square techniques succeeded in identifying such items or how many false positives and negatives occurred. The detection of an item known to be flawed provides one indication that the techniques worked properly. The techniques also displayed trends consistent with earlier studies, such as the Camilli technique yielding more biased items than the Scheuneman (Marascuilo and Slaughter, 1981, discuss why the Scheuneman method is prone to commit Type II errors). More research needs to be done on the relative merits of the two techniques (Berk, 1982). The Camilli X^2 may be theoretically superior, but the Scheuneman may be more feasible in sample size requirements for certain uses.

The computer program worked well and is inexpensive to run. It would benefit from further refinement and modification to make it more suitable for non-technical users. For instance, it could produce item difficulty and discrimination parameters for screening items, and it could compute signed statistics (if only two status groups are involved) to indicate the overall direction of bias. Performance with four or five ability levels is yet to be tested.

There are at least three possible areas for further research on the methodology used to detect item bias in this study. First and most essential is the determination of what rules yield the most appropriate ability intervals (hence cell sizes) and of what effects nonoptimal decisions have. Occasionally moving the cutting point between intervals by one unit can cause dramatic changes in the size of the chi-square statistic and the resulting significance level. If the chi-square approaches aim to provide a useful alternative to expensive and demanding latent-trait methods, they must demonstrate high theoretical validity.

A second need is to refine or develop ways of examining chi-square values for practical significance. As sample size increases, the chance of any inequality between cells to reach statistical significance also increases. Possible ways to depict the size of a bias effect include 1) calculating the percent of deviation from expected value and 2) representing the reduction in errors of prediction resulting from knowledge of an examinee's status group. Such procedures could aid the evaluation of how important a deviation is in practical terms.

Finally, items that have been identified as biased should be studied closely to see what the cause of the bias is. Several new statistical procedures permit analysis of subject-item response patterns. Distractor (foil) analysis is another promising method (Veale and Foreman, 1983).

The chi-square item bias techniques have potential for small-scale test users, who might otherwise settle for glancing at p-values or no bias analysis at all. They offer practical guidance during test development because of low sample size and cost requirements, and are especially well suited to mastery and criterion-referenced tests.

TABLE 1

Significance Level	Items Identified by Both	Items Identified by Scheuneman	Items Identified by Camilli
$p < .05$	22	--	10,12
$p < .10$	22,24,31	27	4,5,10,12,17
$p < .25$	4,5,12,13,17, 22,24,25,27, 31,32	15	10,21

Test range = 0 - 32

Test mean for sixth-grade boys = 11.67 (n = 312)
for sixth-grade girls = 9.93 (n = 285) $F = 8.47$, $p < .001$

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DO=-LONG/-OT,ARG=-COMMON/-FIXED,CS= USER/-FIXED,DB=-TB/-SB/-SL/ ER/-ID/-PMD/-ST,PL=50000
FTN5.

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      PROGRAM BIAS                                                      
*****************************************************************     
*   PROGRAM "BIAS" REQUIRES TWO INPUT DATA FILES                *     
*     1.  A FILE OF EACH SUBJECTS TEST ITEM RESPONSES           *     
*           -THE FIRST FIVE COLUMNS OF EACH RECORD IN THIS FILE ARE *     
*            RESERVED FOR A RESPONDENT IDENTIFICATION NUMBER AND A  *     
*            CARD NUMBER IF REQUIRED.                               *     
*           -COLUMN SIX OF THE FIRST RECORD FOR EACH RESPONDENT MUST *     
*            CONTAIN A STATUS GROUP IDENTIFIER.  FOR TWO STATUS     *     
*            GROUPS THIS CODE MUST BE A "1" OR A "2"; FOR THREE     *     
*            STATUS GROUPS THIS CODE MUST BE A "1", A "2", OR A     *     
*            "3"  ETC.                                              *     
*           -COLUMNS SEVEN THROUGH 80 ARE RESERVED FOR ITEM RESPON- *     
*            SES (ONE ITEM PER COLUMN UP TO THE TOTAL NUMBER OF     *     
*            ITEMS).  IF THERE ARE MORE THAN 74 ITEMS ON THE TEST,  *     
*            RESPONSES TO ITEMS 75-100 ARE RECORDED ON THE SECOND   *     
*            RECORD STARTING IN COLUMN SIX.                         *     
*           -THIS FILE MUST BE ATTACHED USING LOCAL FILE NAME       *     
*            "TEST"                                                 *     
*     2.  THE SECOND FILE MUST CONTAIN INFORMATION REGARDING THE    *     
*         PARAMETERS OF THE DATA ON THE "TEST" FILE:                *     
*           -THE FIRST RECORD OF THIS FILE MUST CONTAIN THE FOLLOW- *     
*            ING VALUES IN FREE FORMAT (ONE OR MORE SPACES BETWEEN  *     
*            EACH VARIABLE) IN THE FOLLOWING ORDER:                 *     
*              NUMSBJ = TOTAL NUMBER OF SUBJECTS (UP TO 1000) FOR   *     
*                       WHOM THERE IS DATA ON THE "TEST" FILE       *     
*              NUMITM = TOTAL NUMBER OF ITEMS ON THE TEST (UP TO    *     
*                       100) FOR WHICH THERE IS DATA ON THE         *     
*                       "TEST" FILE                                 *     
*              NUMGRP = TOTAL NUMBER OF STATUS GROUPS (UP TO 4)     *     
*           -THE SECOND RECORD OF THIS FILE MUST CONTAIN A LABEL    *     
*            FOR EACH OF THE STATUS GROUPS.  THESE LABELS CAN EACH  *     
*            BE UP TO SEVEN CHARACTERS.  EACH LABEL MUST BE ENCLOSED*     
*            IN SINGLE QUOTATION MARKS (E.G. 'MALES' 'FEMALES')     *     
*              GNAME(1) = LABEL FOR STATUS GROUP 1                  *     
*              GNAME(2) = LABEL FOR STATUS GROUP 2                  *     
*                         ETC. FOR EACH STATUS GROUP                *     
*           -THE THIRD AND SUBSEQUENT RECORDS IN THIS FILE MUST     *     
*            CONTAIN THE "CORRECT" RESPONSE TO EACH OF THE TEST     *     
*            ITEMS IN THE "TEST" FILE.  THESE VALUES MUST BE IN     *     
*            FREE FORMAT (AT LEAST ONE BLANK BETWEEN EACH VALUE)    *     
*            AND MAY OCCUPY AS MANY RECORDS AS NECESSARY.  NOTE,    *     
*            THERE MUST BE AS MANY VALUES AS INDICATED BY THE       *     
*            VALUE FOR "NUMITM" ABOVE.                              *     
*           -THIS FILE MUST BE ATTACHED USING LOCAL FILE NAME       *     
*            "KEY".                                                 *     
*---------------------------------------------------------------    *     
*   THE FOLLOWING ARRAYS ARE USED THROUGHOUT PROGRAM "BIAS" AND ITS *     
*   MANY SUBROUTINES:                                               *     
*      ANSWER = THE VALUES OF THE CORRECT ANSWERS FOR EACH ITEM ON  *     
*               THE TEST                                            *     
*      CAMEXP = THE CALCULATED EXPECTED CELL FREQUENCIES FOR AN ITEM*     
*               FOR THE CAMILLI STATISTIC                          *     
*               1ST DIMENSION = ABILITY GROUP                      *     
*               2ND DIMENSION = STATUS GROUP                       *     
*               3RD DIMENSION = (1) FOR INCORRECT RESPONSES        *     
*                               (2) FOR CORRECT RESPONSES          *     
*      CAMOBS = THE OBSERVED CELL FREQUENCIES FOR AN ITEM FOR THE   *     
*               CAMILLI STATISTIC                                  *     
*               (DIMENSIONS SAME AS FOR "CAMEXP" ABOVE)            *     
*      CAPROP = THE PERCENTAGE OF STUDENTS GETTING AN ITEM CORRECT  *     
*               FOR EACH STATUS GROUP IN EACH OF THE ABILITY GROUPS *     
*               USED FOR THE CAMILLI STATISTIC                     *     
*               1ST DIMENSION = ABILITY GROUP                      *     
*               2ND DIMENSION = STATUS GROUP                       *     
*      CUMTIV = THE CUMULATIVE FREQUENCY OF STUDENTS RECEIVING EACH *     
*               POSSIBLE TOTAL TEST SCORE                          *     
*      GROUP  = THE STATUS GROUP IDENTIFIER FOR EACH SUBJECT        *     
*      ITEM   = THE RESPONSES OF EACH SUBJECT TO EACH ITEM.         *     
*               1ST DIMENSION = SUBJECT                            *     
*               2ND DIMENSION = ITEM                               *     
*      NCORCT = TOTAL NUMBE OF SUBJECTS IN AN ABILITY GROUP GETTING *     
*               AN ITEM (1)INCORRECT (2)CORRECT                    *     
*      NGROUP = TOTAL NUMBER OF SUBJECTS IN EACH STATUS GROUP IN AN *     
*               ABILITY GROUP                                      *     
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      *       SCHEXP = THE CALCULATED EXPECTED CELL FREQUENCIES FOR AN ITEM   *
      *                FOR THE SCHEUNEMAN STATISTIC                           *
      *                1ST DIMENSION = ABILITY GROUP                          *
      *                2ND DIMENSION = STATUS GROUP                           *
      *                3RD DIMENSION = (1) FOR INCORRECT RESPONSES            *
      *                                (2) FOR CORRECT RESPONSES              *
      *       SCHOBS = THE OVSERVED CELL FREQUENCIES FOR AN ITEM FOR THE      *
      *                SCHEUNEMAN STATISTIC                                   *
      *                (DIMENSIONS SAME AS FOR "SCHEXP" ABOVE)                *
      *       SCORES = THE NUMBER OF STUDENTS RECEIVING EACH POSSIBLE         *
      *                TOTAL TEST SCORE                                       *
      *       SCPROP = THE PERCENTAGE OF STUDENTS GETTING AN ITEM CORRECT     *
      *                FOR EACH STATUS GROUP IN EACH OF THE ABILITY GROUPS    *
      *                USED FOR THE SCHEUNEMAN STATISTIC                      *
      *       TOTAL  = TOTAL TEST SCORE FOR EACH STUDENT                      *
      ****************************************************************
            INTEGER NUMSBJ,NUMITM,NUMGRP,ITEM(1000,100),TOTAL(1000),
           +   CUMTIV(101),ANSWER(100),SCORES(101),NGROUP(4),
           +   SCHOBS(5,4,2),CAMOBS(5,4,2),GROUP(1000)
            REAL SCHEXP(5,4,2),CAMEXP(5,4,2),SCPROP(5,4),CAPROP(5,4)
            CHARACTER GNAME(4)*7
            OPEN(1,FILE='TEST')
            OPEN(2,FILE='KEY')
            READ(2,*)NUMSBJ,NUMITM,NUMGRP
            READ(2,*)(GNAME(I),I=1,NUMGRP)
            PRINT 100
            PRINT 101
            PRINT 110
            PRINT 120
            PRINT 130
            PRINT 140
            PRINT 150
            PRINT 160
            PRINT 170
            PRINT 180
            PRINT 181
            PRINT 182
            PRINT 183
            PRINT 184
            PRINT 185
            PRINT 190
            PRINT 191
            PRINT 200,NUMSBJ
            PRINT 210,NUMITM
            PRINT 220,NUMGRP
            CALL STEP1(NUMSBJ,NUMITM,NUMGRP,ITEM,TOTAL,GROUP,CUMTIV,ANSWER,
           +           SCORES,NGROUP,SCHOBS,CAMOBS,SCHEXP,CAMEXP,SCPROP,CAPROP,
           +           GNAME)
      100   FORMAT('1',33X,'PROCEDURE DEVELOPED AT MICHIGAN STATE UNIVERSITY')
      101   FORMAT('+',82X,'FOR COMPUTATION OF')
      110   FORMAT(' ',44X,'SCHEUNEMAN AND CAMILLI ITEM BIAS STATISTICS')
      120   FORMAT('0',60X,'VERSION 1.1')
      130   FORMAT(' ',60X,'PROGRAMMERS:')
      140   FORMAT('0',58X,'JANET VREDEVOOGD')
      150   FORMAT(' ',60X,'MARTHA JONES')
      160   FORMAT('0',48X,'DEPARTMENT OF EDUCATIONAL PSYCHOLOGY')
      170   FORMAT(' ',56X,'COLLEGE OF EDUCATION')
      180   FORMAT('0',35X,'THE CAMILLI CHI-SQUARE COMPARES OBSERVED AND')
      181   FORMAT('+',80X,'EXPECTED VALUES')
      182   FORMAT(' ',40X,'FOR BOTH CORRECT AND INCORRECT RESPONSES')
      183   FORMAT(' ',35X,'THE SCHEUNEMAN CHI-SQUARE COMPARES OBSERVED AND')
      184   FORMAT('+',81X,'EXPECTED VALUES')
      185   FORMAT(' ',40X,'FOR CORRECT RESPONSES ONLY')
      190   FORMAT('0',34X,'THE CALCULATIONS FOR THIS RUN ARE BASED ON THE')
      191   FORMAT('+',81X,'FOLLOWING VALUES')
      200   FORMAT('0',56X,'NUMBER OF SUBJECTS =',I5)
      210   FORMAT(' ',59X,'NUMBER OF ITEMS =',I5)
      220   FORMAT(' ',51X,'NUMBER OF STATUS GROUPS =',I5)
            END
```

```
      1           ************************************************************          1630
      2           *   SUBROUTINE STEP1                                       *          1640
      3           ************************************************************          1650
      4                 SUBROUTINE STEP1(NUMSBJ,NUMITM,NUMGRP,ITEM,TOTAL,GROUP,CUMTIV,  1660
      5                +                 ANSWER,SCORES,NGROUP,SCHOBS,CAMOBS,SCHEXP,CAMEXP,1670
      6                +                 SCPROP,CAPROP,GNAME)                           1680
      7                 INTEGER ITEM(NUMSBJ,NUMITM),TOTAL(NUMSBJ),GROUP(NUMSBJ),NUMSBJ, 1690
      8                +    NUMITM,NUMGRP,CUMTIV(NUMITM+1),ANSWER(NUMITM),NGROUP(NUMGRP),1700
      9                +    STARTU,STARTL,SCORES(NUMITM + 1),LASTAN,MATCH,I,J,          1710
     10                +    SCHOBS(5,NUMGRP,2),CAMOBS(5,NUMGRP,2)                      1720
     11                 REAL SCHEXP(5,NUMGRP,2),CAMEXP(5,NUMGRP,2),SCPROP(5,NUMGRP),   1730
     12                +    CAPROP(5,NUMGRP)                                           1740
     13                 CHARACTER GNAME(4)*7                                          1750
     14                 READ(2,*)(ANSWER(I),I=1,NUMITM)                               1760
     15                 DO 5 I=1,(NUMITM + 1)                                         1770
     16                    SCORES(I) = 0                                              1780
     17           5     CONTINUE                                                      1790
     18                 DO 10 I=1,NUMSBJ                                              1800
     19                    IF(NUMITM.LT.75)THEN                                       1810
  1  20                       READ(1,100)GROUP(I),(ITEM(I,J),J=1,NUMITM)              1820
  1  21                    ELSE                                                       1830
  1  22                       READ(1,101)GROUP(I),(ITEM(I,J),J=1,NUMITM)              1840
  1  23                    END IF                                                     1850
     24                    TOTAL(I) = 0                                               1860
     25                    LASTAN = 0                                                 1870
     26                    DO 20 J=1,NUMITM                                           1880
     27                       IF(ITEM(I,J).EQ.ANSWER(J))THEN                          1890
  1  28                          ITEM(I,J) = 2                                        1900
  1  29                          CALL INC(TOTAL(I))                                   1910
  1  30                          LASTAN = J                                           1920
  1  31                       ELSE IF(ITEM(I,J).EQ.0)THEN                             1930
  1  32                          ITEM(I,J) = 9                                        1940
  1  33                       ELSE                                                    1950
  1  34                          ITEM(I,J) = 1                                        1960
  1  35                          LASTAN = J                                           1970
  1  36                       END IF                                                  1980
     37           20       CONTINUE                                                  1990
     38                    DO 21 J=1,LASTAN                                          2000
     39                       IF(ITEM(I,J).EQ.9)THEN                                 2010
  1  40                          ITEM(I,J) = 1                                        2020
  1  41                       END IF                                                  2030
     42           21       CONTINUE                                                  2040
     43                    CALL INC(SCORES(TOTAL(I)+1))                              2050
     44           10    CONTINUE                                                     2060
     45                 CUMTIV(1) = SCORES(1)                                        2070
     46                 DO 30 I=1,NUMITM                                             2080
     47                    J=I+1                                                     2090
     48                    CUMTIV(J) = CUMTIV(I) + SCORES(J)                         2100
     49           30    CONTINUE                                                     2110
     50                 STARTL = NUMSBJ/3                                            2120
     51                 STARTU = NUMSBJ-STARTL                                       2130
     52                 MATCH = 0                                                    2140
     53                 I = 2                                                        2150
     54           *-----REPEAT-----------------------------------------------------* 2160
     55           40    CONTINUE                                                     2170
     56                    IF(CUMTIV(I).GE.STARTL)THEN                               2180
  1  57                       MATCH = 1                                              2190
  1  58                       STARTL = I-2                                           2200
  1  59                    ELSE                                                      2210
  1  60                       I = I + 1                                              2220
  1  61                    END IF                                                    2230
     62                 IF(MATCH.EQ.0)GO TO 40                                       2240
     63           *-----UNTIL MATCH------------------------------------------------* 2250
     64                 MATCH = 0                                                    2260
     65                 I = NUMITM                                                   2270
     66           *-----REPEAT-----------------------------------------------------* 2280
     67           50    CONTINUE                                                     2290
     68                    IF(CUMTIV(I).LE.STARTU)THEN                               2300
  1  69                       MATCH = 1                                              2310
  1  70                       STARTU = I                                             2320
  1  71                    ELSE                                                      2330
  1  72                       I = I - 1                                              2340
  1  73                    END IF                                                    2350
     74                 IF(MATCH.EQ.0)GO TO 50                                       2360
     75           *-----UNTIL MATCH------------------------------------------------* 2370
```

```
      DO 60 I = 1,3                                                     2380
         CALL STEP2(STARTU,STARTL,I,ITEM,NUMITM,NUMSBJ,NUMGRP,GROUP,    2390
     +              TOTAL,NGROUP,SCHOBS,CAMOBS,SCHEXP,CAMEXP,SCPROP,    2400
     +              CAPROP,GNAME)                                       2410
60    CONTINUE                                                          2420
      RETURN                                                            2430
100   FORMAT(5X,75I1)                                                   2440
101   FORMAT(5X,75I1/5X,75I1)                                           2450
      END                                                               2460
```

```
SUBROUTINE STEP2      74/175  OPT=1,ROUND= A/ S/ M/-D,-DS     FTN 5.1+587        04/20/84 .01.27.19       PAGE      1
DO=-LONG/-OT,ARG=-COMMON/-FIXED,CS= USER/-FIXED,DB=-TB/-SB/-SL/ ER/-ID/-PMD/-ST,PL=50000
FTN5.

      1           ************************************************************************      2470
      2           *   SUBROUTINE STEP2                                                   *      2480
      3           ************************************************************************      2490
      4                 SUBROUTINE STEP2(STARTU,STARTL,I,ITEM,NUMITM,NUMSBJ,NUMGRP,GROUP,     2500
      5                +                 TOTAL,NGROUP,SCHOBS,CAMOBS,SCHEXP,CAMEXP,SCPROP,     2510
      6                +                 CAPROP,GNAME)                                        2520
      7                 INTEGER UPPER,LOWER,I,ITEM(NUMSBJ,NUMITM),NUMSBJ,NUMITM,SNUMAG,     2530
      8                +   TOTAL(NUMSBJ),NGROUP(NUMGRP),NCORCT(2),GROUP(NUMSBJ),CNUMAG,      2540
      9                +   NABGRP(5),SCHOBS(5,NUMGRP,2),CAMOBS(5,NUMGRP,2)                   2550
     10                +   CHECK,NUMGRP,MIDLOW,MIDUP,SCMIDL,SCMIDU,SCMNL,SCMNU,J,K,          2560
     11                +   L,STARTU,STARTL                                                   2570
     12                 REAL SCHEXP(5,NUMGRP,2),CAMEXP(5,NUMGRP,2),CASTAT,SCSTAT,CAPROB,     2580
     13                +   SCPROB,SCPROP(5,NUMGRP),CAPROP(5,NUMGRP)                         2590
     14                 CHARACTER GNAME(4)*7                                                2600
     15                 SNUMAG = 3                                                          2610
     16                 CNUMAG = 3                                                          2620
     17                 LOWER = STARTL - 1                                                  2630
     18                 SCMNL = 0                                                           2640
     19           *-----REPEAT-------------------------------------------------------------*      2650
     20           10    CONTINUE                                                            2660
     21                    CALL SET(NABGRP,NGROUP,NCORCT,CAMOBS,NUMGRP,1)                   2670
     22                    CALL INC(LOWER)                                                  2680
     23                    DO 20 J=1,NUMSBJ                                                 2690
     24                       IF((TOTAL(J).LE.LOWER).AND.(ITEM(J,I).NE.9))THEN              2700
  1  25                          CALL COUNTO(GROUP(J),ITEM(J,I),NABGRP,NGROUP,NCORCT,       2710
  1  26                +            NUMGRP,CAMOBS,1)                                      2720
  1  27                       END IF                                                        2730
     28           20       CONTINUE                                                         2740
     29                    CALL CALCEX(SCHEXP,CAMEXP,SCHOBS,CAMOBS,NGROUP,NCORCT,NABGRP,    2750
     30                +               NUMGRP,1,LOWER,SCMNL,SCPROP)                         2760
     31                    CHECK = 1                                                        2770
     32                    DO 21 J=1,NUMGRP                                                 2780
     33                       DO 22 K=1,2                                                   2790
     34                          IF(CAMEXP(1,J,K).LT.5)THEN                                 2800
  1  35                             CHECK = 0                                               2810
  1  36                          END IF                                                     2820
     37           22          CONTINUE                                                      2830
     38           21       CONTINUE                                                         2840
     39                 IF(CHECK.EQ.0)GO TO 10                                             2850
     40           *-----UNTIL ALL EXPECTED CELL FREQUENCIES GE 5 FOR LOWER DIVISION-------*      2860
     41                 DO 25 J=1,NUMGRP                                                   2870
     42                    CAPROP(1,J) = (100.0*CAMOBS(1,J,2))/NGROUP(J)                   2880
     43           25    CONTINUE                                                          2890
     44                 UPPER = STARTU + 1                                                 2900
     45                 SCMNU = 0                                                          2910
     46           *-----REPEAT-------------------------------------------------------------*      2920
     47           30    CONTINUE                                                          2930
     48                    CALL SET(NABGRP,NGROUP,NCORCT,CAMOBS,NUMGRP,3)                  2940
     49                    UPPER = UPPER - 1                                               2950
     50                    DO 40 J=1,NUMSBJ                                                2960
     51                       IF((TOTAL(J).GE.UPPER).AND.(ITEM(J,I).NE.9))THEN             2970
  1  52                          CALL COUNTO(GROUP(J),ITEM(J,I),NABGRP,NGROUP,NCORCT,       2960
  1  53                +            NUMGRP,CAMOBS,3)                                      2990
  1  54                       END IF                                                        3000
     55           40       CONTINUE                                                        3010
     56                    CALL CALCEX(SCHEXP,CAMEXP,SCHOBS,CAMOBS,NGROUP,NCORCT,NABGRP,    3020
     57                +      NUMGRP,3,UPPER,SCMNU,SCPROP)                                 3030
     58                    CHECK = 1                                                       3040
     59                    DO 41 J=1,NUMGRP                                                3050
     60                       DO 42 K=1,2                                                  3060
     61                          IF(CAMEXP(3,J,K).LT.5)THEN                                3070
  1  62                             CHECK = 0                                              3080
  1  63                          END IF                                                    3090
     64           42          CONTINUE                                                     3100
     65           41       CONTINUE                                                        3110
     66                 IF(CHECK.EQ.0)GO TO 30                                             3120
     67           *-----UNTIL ALL EXPECTED CELL FREQUENCIES GE 5 FOR UPPER DIVISION------*      3130
     68                 DO 45 J=1,NUMGRP                                                   3140
     69                    CAPROP(3,J) = (100.0*CAMOBS(3,J,2))/NGROUP(J)                   3150
     70           45    CONTINUE                                                          3160
     71                 IF((UPPER - LOWER).LE.1)THEN                                       3170
  1  72                    CNUMAG = 0                                                      3180
  1  73                    IF((SCMNU - SCMNL).LE.1)THEN                                    3190
  2  74                       SNUMAG = 0                                                   3200
  2  75                    ELSE                                                            3210
```

```
2   76                  CALL SCHMID(SCHOBS,NUMSBJ,NUMGRP,TOTAL,GROUP,ITEM,                3220
2   77                +    NGROUP,NCORCT,NABGRP,NUMITM,SCMNL,SCMNU,I)                   3230
2   78                  CHECK = 1                                                       3240
2   79                  DO 50 J=1,NUMGRP                                                3250
2   80                     SCHEXP(2,J,2) = (1.0*NGROUP(J)*NCORCT(2))/NABGRP(2)          3260
2   81                     IF(SCHEXP(2,J,2).LT.5)THEN                                   3270
3   82                        CHECK = 0                                                 3280
3   83                     END IF                                                       3290
2   84            50       CONTINUE                                                     3300
2   85                  IF(CHECK.EQ.0)THEN                                              3310
3   86                     SNUMAG = 0                                                   3320
3   87                  ELSE                                                            3330
3   88                     DO 55 J=1,NUMGRP                                             3340
3   89                        SCPROP(2,J) = (100.0*SCHOBS(2,J,2))/NGROUP(J)             3350
3   90            55          CONTINUE                                                  3360
3   91                        CALL STATS(SCHOBS,SCHEXP,SNUMAG,NUMGRP,SCSTAT,SCPROB)     3370
3   92                     END IF                                                       3380
2   93                END IF                                                          3390
1   94              ELSE                                                              3400
1   95                CALL SET(NABGRP,NGROUP,NCORCT,CAMOBS,NUMGRP,2)                  3410
1   96                DO 60 J=1,NUMSBJ                                                3420
1   97                   IF((TOTAL(J).GT.LOWER).AND.(TOTAL(J).LT.UPPER).AND.          3430
1   98                +     (ITEM(J,I).NE.9))THEN                                     3440
2   99                      CALL COUNTO(GROUP(J),ITEM(J,I),NABGRP,NGROUP,NCORCT,      3450
2  100                +        NUMGRP,CAMOBS,2)                                       3460
2  101                   END IF                                                       3470
1  102            60     CONTINUE                                                     3480
1  103                   CHECK = 1                                                    3490
1  104                   DO 61 J=1,NUMGRP                                             3500
1  105                      DO 62 K=1,2                                               3510
1  106                         CAMEXP(2,J,K) = (1.0*NGROUP(J)*NCORCT(K)/NABGRP(2))    3520
1  107                         IF(CAMEXP(2,J,K).LT.5)THEN                             3530
2  108                            CHECK = 0                                           3540
2  109                         END IF                                                 3550
1  110            62        CONTINUE                                                  3560
1  111            61     CONTINUE                                                     3570
1  112                   IF(CHECK.EQ.0)THEN                                           3580
2  113                      CNUMAG = 0                                                3590
2  114                   ELSE                                                         3600
2  115                      DO 66 J=1,NUMGRP                                          3610
2  116                         CAPROP(2,J) = (100.0*CAMOBS(2,J,2))/NGROUP(J)          3620
2  117            66        CONTINUE                                                  3630
2  118                      CASTAT = 0.0                                              3640
2  119                      DO 63 J=1,CNUMAG                                          3650
2  120                         DO 64 K=1,NUMGRP                                       3660
2  121                            DO 65 L=1,2                                         3670
2  122                               CASTAT=CASTAT + (((CAMEXP(J,K,L)-CAMOBS(J,K,L))**2)  3680
2  123                +                 /CAMEXP(J,K,L))                               3690
2  124            65                 CONTINUE                                        3700
2  125            64                CONTINUE                                         3710
2  126            63             CONTINUE                                            3720
2  127                      IF(CASTAT.GT.16.266)THEN                                  3730
2  128                         CAPROB = .001                                          3740
3  129                      ELSE IF(CASTAT.GT.12.8381)THEN                            3750
3  130                         CAPROB = .005                                          3760
3  131                      ELSE IF(CASTAT.GT.11.3449)THEN                            3770
3  132                         CAPROB = .01                                           3780
3  133                      ELSE IF(CASTAT.GT.9.3484)THEN                             3790
3  134                         CAPROB = .025                                          3800
3  135                      ELSE IF(CASTAT.GT.7.81473)THEN                            3810
3  136                         CAPROB = .05                                           3820
3  137                      ELSE IF(CASTAT.GT.6.25139)THEN                            3830
3  138                         CAPROB = .10                                           3840
3  139                      ELSE IF(CASTAT.GT.4.10835)THEN                            3850
3  140                         CAPROB = .25                                           3860
3  141                      ELSE                                                      3870
3  142                         CAPROB = 999                                           3880
3  143                      END IF                                                    3890
2  144                   END IF                                                       3900
1  145                   CALL SCHMID(SCHOBS,NUMSBJ,NUMGRP,TOTAL,GROUP,ITEM,           3910
1  146                +     NGROUP,NCORCT,NABGRP,NUMITM,SCMNL,SCMNU,I)                3920
1  147                   CHECK = 1                                                    3930
1  148                   DO 70 J=1,NUMGRP                                             3940
1  149                      SCHEXP(2,J,2) = (1.0*NGROUP(J)*NCORCT(2)/NABGRP(2))       3950
1  150                      IF(SCHEXP(2,J,2).LT.5)THEN                                3960
2  151                         CHECK = 0                                              3970
2  152                      END IF                                                    3980
```

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1  153          70       CONTINUE                                                          3990
1  154                   IF(CHECK.EQ.0)THEN                                                4000
2  155                      SNUMAG = 0                                                     4010
2  156                   ELSE                                                              4020
2  157                      DO 75 J=1,NUMGRP                                               4030
2  158                         SCPROP(2,J) = (100.0*SCHOBS(2,J,2))/NGROUP(J)               4040
2  159             75       CONTINUE                                                       4050
2  160                      CALL STATS(SCHOBS,SCHEXP,SNUMAG,NUMGRP,SCSTAT,SCPROB)          4060
2  161                   END IF                                                            4070
1  162                END IF                                                               4080
   163                IF(CNUMAG.EQ.0)THEN                                                  4090
1  164                   IF(SNUMAG.EQ.0)THEN                                            4100
2  165                      PRINT 100                                                      4110
2  166                      PRINT 101                                                      4120
2  167                      PRINT 200,I                                                    4130
2  168                      PRINT 201,I                                                    4140
2  169                   ELSE                                                           4150
2  170                      PRINT 100                                                      4160
2  171                      PRINT 101                                                      4170
2  172                      PRINT 111,I,SCSTAT                                             4180
2  173                      PRINT 200,I                                                    4190
2  174                      IF(SCPROB.EQ.999)THEN                                          4200
3  175                         PRINT 211                                                   4210
3  176                      ELSE                                                           4220
3  177                         PRINT 222,SCPROB                                            4230
3  178                      END IF                                                         4240
2  179                      PRINT 301                                                      4250
2  180                      PRINT 311                                                      4260
2  181                      PRINT 401,I                                                    4270
2  182                      PRINT 411                                                      4280
2  183                      PRINT 502                                                      4290
2  184                      IF(SNUMAG.EQ.3)THEN                                            4300
3  185                         PRINT 632,SCMNL,(SCMNL+1),(SCMNU-1),SCMNU,NUMITM            4310
3  186                         DO 80 K=1,NUMGRP                                            4320
3  187                            PRINT 732,GNAME(K),(SCPROP(J,K),J=1,3)                   4330
3  188             80          CONTINUE                                                    4340
3  189                      ELSE IF(SNUMAG.EQ.4)THEN                                       4350
3  190                         PRINT 642,SCMNL,(SCMNL+1),SCMIDL,(SCMIDL+1),(SCMNU-1),      4360
3  191              +             SCMNU,NUMITM                                            4370
3  192                         DO 81 K=1,NUMGRP                                            4380
3  193                            PRINT 742,GNAME(K),(SCPROP(J,K),J=1,4)                   4390
3  194             81          CONTINUE                                                    4400
3  195                      ELSE                                                           4410
3  196                         PRINT 652,SCMNL,(SCMNL+1),SCMIDL,(SCMIDL+1),(SCMIDU-1),     4420
3  197              +             SCMIDU,(SCMNU-1),SCMNU,NUMITM                           4430
3  198                         DO 82 K=1,NUMGRP                                            4440
3  199                            PRINT 752,GNAME(K),(SCPROP(J,K),J=1,5)                   4450
3  200             82          CONTINUE                                                    4460
3  201                      END IF                                                         4470
2  202                   END IF                                                            4480
1  203                ELSE                                                              4490
1  204                   PRINT 100                                                      4500
1  205                   PRINT 110,I,CASTAT                                             4510
1  206                   PRINT 101                                                      4520
1  207                   PRINT 111,I,SCSTAT                                             4530
1  208                   IF(CAPROB.EQ.999)THEN                                          4540
2  209                      PRINT 210                                                   4550
2  210                   ELSE                                                           4560
2  211                      PRINT 220,CAPROB                                            4570
2  212                   END IF                                                         4580
1  213                   IF(SCPROB.EQ.999)THEN                                          4590
2  214                      PRINT 211                                                   4600
2  215                   ELSE                                                           4610
2  216                      PRINT 221,SCPROB                                            4620
2  217                   END IF                                                         4630
1  218                   PRINT 300                                                      4640
1  219                   PRINT 310                                                      4650
1  220                   PRINT 400,I                                                    4660
1  221                   PRINT 410                                                      4670
1  222                   PRINT 500                                                      4680
1  223                   PRINT 501                                                      4690
1  224                   IF(CNUMAG.EQ.5)THEN                                            4700
2  225                      PRINT 650,LOWER,(LOWER+1),MIDLOW,(MIDLOW+1),(MIDUP-1),MIDUP, 4710
2  226              +          (UPPER-1),UPPER,NUMITM                                   4720
2  227                      PRINT 651,SCMNL,(SCMNL+1),SCMIDL,(SCMIDL+1),(SCMIDU-1),     4730
2  228              +          SCMIDU,(SCMNU-1),SCMNU,NUMITM                            4740
2  229                      DO 90 K=1,NUMGRP                                            4750
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      PRINT 750,GNAME(K),(CAPROP(J,K),J=1,5)                            4760
      PRINT 751,GNAME(K),(SCPROP(J,K),J=1,5)                            4770
   90 CONTINUE                                                          4780
   ELSE IF(CNUMAG.EQ.4)THEN                                             4790
      IF(SNUMAG.EQ.4)THEN                                               4800
         PRINT 640,LOWER,(LOWER+1),MIDLOW,(MIDLOW+1),(UPPER-1),         4810
     +      UPPER,NUMITM                                                4820
         PRINT 641,SCMNL,(SCMNL+1),SCMIDL,(SCMIDL+1),(SCMNU-1),         4830
     +      SCMNU,NUMITM                                                4840
         DO 91 K=1,NUMGRP                                               4850
            PRINT 740,GNAME(K),(CAPROP(J,K),J=1,4)                      4860
            PRINT 741,GNAME(K),(SCPROP(J,K),J=1,4)                      4870
   91    CONTINUE                                                       4880
      ELSE                                                              4890
         PRINT 640,LOWER,(LOWER+1),MIDLOW,(MIDLOW+1),(UPPER-1),         4900
     +      UPPER,NUMITM                                                4910
         PRINT 651,SCMNL,(SCMNL+1),SCMIDL,(SCMIDL+1),(SCMIDU-1),        4920
     +      SCMIDU,(SCMNU-1),SCMNU,NUMITM                               4930
         DO 92 K=1,NUMGRP                                               4940
            PRINT 740,GNAME(K),(CAPROP(J,K),J=1,4)                      4950
            PRINT 751,GNAME(K),(SCPROP(J,K),J=1,5)                      4960
   92    CONTINUE                                                       4970
      END IF                                                            4980
   ELSE                                                                 4990
      IF(SNUMAG.EQ.3)THEN                                               5000
         PRINT 630,LOWER,(LOWER+1),(UPPER-1),UPPER,NUMITM               5010
         PRINT 631,SCMNL,(SCMNL+1),(SCMNU-1),SCMNU,NUMITM               5020
         DO 93 K=1,NUMGRP                                               5030
            PRINT 730,GNAME(K),(CAPROP(J,K),J=1,3)                      5040
            PRINT 731,GNAME(K),(SCPROP(J,K),J=1,3)                      5050
   93    CONTINUE                                                       5060
      ELSE IF(SNUMAG.EQ.4)THEN                                          5070
         PRINT 630,LOWER,(LOWER+1),(UPPER-1),UPPER,NUMITM               5080
         PRINT 641,SCMNL,(SCMNL+1),SCMIDL,(SCMIDL+1),(SCMNU-1),         5090
     +      SCMNU,NUMITM                                                5100
         DO 94 K=1,NUMGRP                                               5110
            PRINT 730,GNAME(K),(CAPROP(J,K),J=1,3)                      5120
            PRINT 741,GNAME(K),(SCPROP(J,K),J=1,4)                      5130
   94    CONTINUE                                                       5140
      ELSE                                                              5150
         PRINT 630,LOWER,(LOWER+1),(UPPER-1),UPPER,NUMITM               5160
         PRINT 651,SCMNL,(SCMNL+1),SCMIDL,(SCMIDL+1),(SCMIDU-1),        5170
     +      SCMIDU,(SCMNU-1),SCMNU,NUMITM                               5180
         DO 95 K=1,NUMGRP                                               5190
            PRINT 730,GNAME(K),(CAPROP(J,K),J=1,3)                      5200
            PRINT 751,GNAME(K),(SCPROP(J,K),J=1,5)                      5210
   95    CONTINUE                                                       5220
      END IF                                                            5230
   END IF                                                               5240
END IF                                                                  5250
RETURN                                                                  5260
100 FORMAT('2','CAMILLI CHI-SQUARE FULL')                               5270
101 FORMAT('+',75X,'SCHEUNEMAN CHI-SQUARE CORRECT')                     5280
110 FORMAT('+',24X,'FOR ITEM #',I4,'= ',F7.3)                           5290
111 FORMAT('+',105X,'FOR ITEM #',I4,'= ',F7.3)                          5300
200 FORMAT(' ',' CANNOT BE COMPUTED FOR ITEM #',I4)                     5310
201 FORMAT('+',75X,'CANNOT BE COMPUTED FOR ITEM #',I4)                  5320
210 FORMAT(' ',' D.F. = 3; PROBABILITY GREATER THAN .25')               5330
211 FORMAT('+',75X,'D.F. = 2; PROBABILITY GREATER THAN .25')            5340
220 FORMAT(' ',' D.F. = 3; PROBABILITY LESS THAN',F5.3)                 5350
221 FORMAT('+',75X,'D.F. = 2; PROBABILITY LESS THAN',F5.3)              5360
222 FORMAT(' ',75X,'D.F. = 2; PROBABILITY LESS THAN',F5.3)              5370
300 FORMAT('0',25X,'PERCENTAGE OF STUDENTS FROM EACH STATUS GROUP')     5380
301 FORMAT('0',60X,'PERCENTAGE OF STUDENTS FROM EACH STATUS GROUP')     5390
310 FORMAT('+',71X,'GIVING CORRECT RESPONSES')                          5400
311 FORMAT('+',106X,'GIVING CORRECT RESPONSES')                         5410
400 FORMAT(' ',25X,'FOR ITEM #',I4,' FOR EACH ABILITY GROUP AS')        5420
401 FORMAT(' ',60X,'FOR ITEM #',I4,' FOR EACH ABILITY GROUP AS')        5430
410 FORMAT('+',66X,'DETERMINED BY TOTAL TEST SCORES')                   5440
411 FORMAT('+',101X,'DETERMINED BY TOTAL TEST SCORES')                  5450
500 FORMAT('0',22X,'TOTAL TEST SCORES')                                 5460
501 FORMAT('+',98X,'TOTAL TEST SCORES')                                 5470
502 FORMAT('0',98X,'TOTAL TEST SCORES')                                 5480
630 FORMAT('0',13X,'0-',I3,I11,'-',I3,I11,'-',I4)                       5490
631 FORMAT('+',87X,'0-',I3,I11,'-',I3,I10,'-',I4)                       5500
632 FORMAT('0',87X,'0-',I3,I11,'-',I3,I10,'-',I4)                       5510
640 FORMAT('0',11X,'0-',I3,I8,'-',I3,I8,'-',I3,I8,'-',I4)               5520
```

```
307          641   FORMAT('+',86X,'O-',I3,I8,'-',I3,I8,'-',I3,I8,'-',I4)                    5530
308          642   FORMAT('O',86X,'O-',I3,I8,'-',I3,I8,'-',I3,I8,'-',I4)                    5540
309          650   FORMAT('O',9X,'O-',I3,I5,'-',I3,I5,'-',I3,I5,'-',I3,I5,'-',I4)           5550
310          651   FORMAT('+',84X,'O-',I3,I5,'-',I3,I5,'-',I3,I5,'-',I3,I5,'-',I4)          5560
311          652   FORMAT('O',84X,'O-',I3,I5,'-',I3,I5,'-',I3,I5,'-',I3,I5,'-',I4)          5570
312          730   FORMAT('O',A7,F10.1,F15.1,F16.1)                                          5580
313          731   FORMAT('+',75X,A7,F9.1,F15.1,F15.1)                                       5590
314          732   FORMAT('O',75X,A7,F9.1,F15.1,F15.1)                                       5600
315          740   FORMAT('O',A7,F10.1,F12.1,2F13.1)                                         5610
316          741   FORMAT('+',75X,A7,F10.1,F12.1,2F13.1)                                     5620
317          742   FORMAT('O',75X,A7,F10.1,F12.1,2F13.1)                                     5630
318          750   FORMAT('O',A7,F7.1,F9.1,3F10.1)                                           5640
319          751   FORMAT('+',75X,A7,F7.1,F9.1,3F10.1)                                       5650
320          752   FORMAT('O',75X,A7,F7.1,F9.1,3F10.1)                                       5660
321                END                                                                       5670
```

```
SUBROUTINE COUNTO      74/175  OPT=1,ROUND= A/ S/ M/-D,-DS      FTN 5.1+587        04/20/84 .01.27.19        PAGE      1
DO=-LONG/-OT,ARG=-COMMON/-FIXED,CS= USER/-FIXED,DB=-TB/-SB/-SL/ ER/-ID/-PMD/-ST,PL=50000
FTN5.

      1              ************************************************************************          5680
      2              *   SUBROUTINE COUNTO                                                  *          5690
      3              ************************************************************************          5700
      4                    SUBROUTINE COUNTO(GROUP,ITEM,NABGRP,NGROUP,NCORCT,NUMGRP,                   5710
      5                   +   OBSRVD,I)                                                               5720
      6                    INTEGER GROUP,ITEM,NABGRP(5),NGROUP(NUMGRP),NCORCT(2),NUMGRP,I,            5730
      7                   +   OBSRVD(5,NUMGRP,2)                                                      5740
      8                    IF((GROUP.NE.0).AND.(GROUP.LE.NUMGRP))THEN                                  5750
1     9                       CALL INC(NABGRP(I))                                                      5760
1    10                       CALL INC(NGROUP(GROUP))                                                  5770
1    11                       CALL INC(NCORCT(ITEM))                                                   5780
1    12                       CALL INC(OBSRVD(I,GROUP,ITEM))                                           5790
1    13                    END IF                                                                      5800
     14                    RETURN                                                                      5810
     15                    END                                                                         5820
```

```
SUBROUTINE SET        74/175  OPT=1,ROUND= A/ S/ M/-D,-DS     FTN 5.1+587        04/20/84 .01.27.19       PAGE     1
DO=-LONG/-OT,ARG=-COMMON/-FIXED,CS= USER/-FIXED,DB=-TB/-SB/-SL/ ER/-ID/-PMD/-ST,PL=50000
FTN5.

      ************************************************************************          5830
      *   SUBROUTINE SET                                                     *          584C
      ************************************************************************          5850
            SUBROUTINE SET(NABGRP,NGROUP,NCORCT,OBSRVD,NUMGRP,I)                        5860
            INTEGER NABGRP(5),NGROUP(NUMGRP),NCORCT(2),OBSRVD(5,NUMGRP,2),              5870
           +   NUMGRP,I,J,K                                                             5880
            NABGRP(I) = 0                                                               5890
            DO 10 J=1,NUMGRP                                                            5900
               NGROUP(J) = 0                                                            5910
               DO 20 K=1,2                                                              5920
                  OBSRVD(I,J,K) = 0                                                     5930
      20       CONTINUE                                                                 5940
      10    CONTINUE                                                                    5950
            NCORCT(1) = 0                                                               5960
            NCORCT(2) = 0                                                               5970
            RETURN                                                                      5980
            END                                                                         5990
```

```
SUBROUTINE CALCEX      74/175  OPT=1,ROUND= A/ S/ M/-D,-DS      FTN 5.1+587          04/20/84 .01.27.19        PAGE      1
DO=-LONG/-OT,ARG=-COMMON/-FIXED,CS= USER/-FIXED,DB=-TB/-SB/-SL/ ER/-ID/-PMD/-ST,PL=50000
FTN5.

      1           ************************************************************************        6000
      2           *   SUBROUTINE CALCEX                                                  *        6010
      3           ************************************************************************        6020
      4                 SUBROUTINE CALCEX(SCHEXP,CAMEXP,SCHOBS,CAMOBS,NGROUP,NCORCT,              6030
      5                +   NABGRP,NUMGRP,I,BREAK,BRKSC,SCPROP)                                    6040
      6                 INTEGER NGROUP(NUMGRP),NCORCT(2),NABGRP(5),NUMGRP,I,BREAK,               6050
      7                +   SCHOBS(5,NUMGRP,2),CAMOBS(5,NUMGRP,2),BRKSC,J,K,L,CHECK               6060
      8                 REAL SCHEXP(5,NUMGRP,2),CAMEXP(5,NUMGRP,2),SCPROP(5,NUMGRP)              6070
      9                 DO 10 J=1,NUMGRP                                                         6080
     10                    DO 20 K=1,2                                                           6090
     11                       CAMEXP(I,J,K) = (1.0*NGROUP(J)*NCORCT(K))/NABGRP(I)                6100
     12           20       CONTINUE                                                             6110
     13           10    CONTINUE                                                                6120
     14                 IF(BRKSC.EQ.0)THEN                                                       6130
1    15                    CHECK = 1                                                             6140
1    16                    DO 30 J=1,NUMGRP                                                      6150
1    17                       IF(CAMEXP(I,J,2).LT.5)THEN                                         6160
2    18                          CHECK = 0                                                       6170
2    19                       END IF                                                             6180
1    20           30       CONTINUE                                                             6190
1    21                    IF(CHECK.EQ.1)THEN                                                    6200
2    22                       BRKSC = BREAK                                                      6210
2    23                       DO 40 J=1,NUMGRP                                                   6220
2    24                          SCHEXP(I,J,2) = CAMEXP(I,J,2)                                   6230
2    25                          SCHOBS(I,J,2) = CAMOBS(I,J,2)                                   6240
2    26                          SCPROP(I,J) = (100.0*SCHOBS(I,J,2))/NGROUP(J)                   6250
2    27           40          CONTINUE                                                          6260
2    28                    END IF                                                               6270
1    29                 END IF                                                                  6280
     30                 RETURN                                                                  6290
     31                 END                                                                     6300
```

```
SUBROUTINE SCHMID      74/175  OPT=1,ROUND= A/ S/ M/-D,-DS      FTN 5.1+587          04/20/84 .01.27.19        PAGE     1
DO=-LONG/-OT,ARG=-COMMON/-FIXED,CS= USER/-FIXED,DB=-TB/-SB/-SL/ ER/-ID/-PMD/-ST,PL=50000
FTN5.

      1            ************************************************************************          6310
      2            *   SUBROUTINE SCHMID                                                  *          6320
      3            ************************************************************************          6330
      4                  SUBROUTINE SCHMID(OBSRVD,NUMSBJ,NUMGRP,TOTAL,GROUP,ITEM,                    6340
      5                 +    NGROUP,NCORCT,NABGRP,NUMITM,LOWER,UPPER,I)                            6350
      6                  INTEGER OBSRVD(5,NUMGRP,2),TOTAL(NUMSBJ),NUMSBJ,NUMGRP,NABGRP(5),          6360
      7                 +    NGROUP(NUMGRP),GROUP(NUMSBJ),ITEM(NUMSBJ,NUMITM),                     6370
      8                 +    NCORCT(2),LOWER,UPPER,I                                               6380
      9                  CALL SET(NABGRP,NGROUP,NCORCT,OBSRVD,NUMGRP,2)                             6390
     10                  DO 10 J=1,NUMSBJ                                                          6400
     11                     IF((TOTAL(J).GT.LOWER).AND.(TOTAL(J).LT.UPPER).AND.(ITEM(J,I)          6410
     12                 +       .NE.9))THEN                                                        6420
  1  13                        CALL COUNTO(GROUP(J),ITEM(J,I),NABGRP,NGROUP,NCORCT,NUMGRP,        6430
  1  14                 +          OBSRVD,2)                                                       6440
  1  15                     END IF                                                                 6450
     16            10    CONTINUE                                                                  6460
     17                  RETURN                                                                    6470
     18                  END                                                                       6480
```

```
SUBROUTINE STATS      74/175  OPT=1,ROUND= A/ S/ M/-D,-DS     FTN 5.1+587        04/20/84 .01.27.19       PAGE     1
DO=-LONG/-OT,ARG=-COMMON/-FIXED,CS= USER/-FIXED,DB=-TB/-SB/-SL/ ER/-ID/-PMD/-ST,PL=50000
FTN5.

      1            ************************************************************************      6490
      2            *   SUBROUTINE STATS                                                   *      6500
      3            ************************************************************************      6510
      4                  SUBROUTINE STATS(OBSRVD,EXPCTD,NUMABG,NUMGRP,STAT,PROB)             6520
      5                  INTEGER OBSRVD(5,NUMGRP,2),NUMABG,NUMGRP,I,J                        6530
      6                  REAL EXPCTD(5,NUMGRP,2),STAT,PROB                                   6540
      7                  STAT = 0.0                                                          6550
      8                  DO 10 I=1,NUMABG                                                    6560
      9                     DO 20 J=1,NUMGRP                                                 6570
     10                        STAT = STAT + (((EXPCTD(I,J,2)-OBSRVD(I,J,2))**2)/           6580
     11                 +                    EXPCTD(I,J,2))                                 6590
     12            20       CONTINUE                                                         6600
     13            10    CONTINUE                                                            6610
     14                  IF(STAT.GT.13.816)THEN                                              6620
  1  15                     PROB = .001                                                      6630
  1  16                  ELSE IF(STAT.GT.10.5966)THEN                                        6640
  1  17                     PROB = .005                                                      6650
  1  18                  ELSE IF(STAT.GT.9.21034)THEN                                        6660
  1  19                     PROB = .01                                                       6670
  1  20                  ELSE IF(STAT.GT.7.37776)THEN                                        6680
  1  21                     PROB = .025                                                      6690
  1  22                  ELSE IF(STAT.GT.5.99147)THEN                                        6700
  1  23                     PROB = .05                                                       6710
  1  24                  ELSE IF(STAT.GT.4.60517)THEN                                        6720
  1  25                     PROB = .10                                                       6730
  1  26                  ELSE IF(STAT.GT.2.77259)THEN                                        6740
  1  27                     PROB = .25                                                       6750
  1  28                  ELSE                                                                6760
  1  29                     PROB = 999                                                       6770
  1  30                  END IF                                                              6780
     31                  RETURN                                                              6790
     32                  END                                                                 6800
```

```
SUBROUTINE INC         74/175  OPT=1,ROUND= A/ S/ M/-D,-DS     FTN 5.1+587          04/20/84 .01.27.19        PAGE      1
DO=-LONG/-OT,ARG=-COMMON/-FIXED,CS= USER/-FIXED,DB=-TB/-SB/-SL/ ER/-ID/-PMD/-ST,PL=50000
FTN5.

1               ************************************************************************          6810
2               *   SUBROUTINE INC                                                     *          6820
3               ************************************************************************          6830
4                     SUBROUTINE INC(VAR)                                                         6840
5                     INTEGER VAR                                                                 6850
6                     VAR = VAR + 1                                                               6860
7                     RETURN                                                                      6870
8                     END                                                                         6880
```

PROCEDURE DEVELOPED AT MICHIGAN STATE UNIVERSITY FOR COMPUTATION OF
SCHEUNEMAN AND CAMILLI ITEM BIAS STATISTICS

VERSION 1.1
PROGRAMMERS:

JANET VREDEVOOGD
MARTHA JONES

DEPARTMENT OF EDUCATIONAL PSYCHOLOGY
COLLEGE OF EDUCATION

THE CAMILLI CHI-SQUARE COMPARES OBSERVED AND EXPECTED VALUES
FOR BOTH CORRECT AND INCORRECT RESPONSES
THE SCHEUNEMAN CHI-SQUARE COMPARES OBSERVED AND EXPECTED VALUES
FOR CORRECT RESPONSES ONLY

THE CALCULATIONS FOR THIS RUN ARE BASED ON THE FOLLOWING VALUES

NUMBER OF SUBJECTS = 598
NUMBER OF ITEMS = 32
NUMBER OF STATUS GROUPS = 2

CAMILLI CHI-SQUARE FULL FOR ITEM # 1= 3.684
D.F. = 3; PROBABILITY GREATER THAN .25

SCHEUNEMAN CHI-SQUARE CORRECT FOR ITEM # 1= 1.405
D.F. = 2; PROBABILITY GREATER THAN .25

PERCENTAGE OF STUDENTS FROM EACH STATUS GROUP GIVING CORRECT RESPONSES
FOR ITEM # 1 FOR EACH ABILITY GROUP AS DETERMINED BY TOTAL TEST SCORES

	TOTAL TEST SCORES		
	0- 7	8- 12	13- 32
MALES	20.0	43.3	84.0
FEMALES	26.7	44.0	75.0

	TOTAL TEST SCORES		
	0- 7	8- 12	13- 32
MALES	20.0	43.3	84.0
FEMALES	26.7	44.0	75.0

CAMILLI CHI-SQUARE FULL FOR ITEM # 2= 3.377
D.F. = 3; PROBABILITY GREATER THAN .25

SCHEUNEMAN CHI-SQUARE CORRECT FOR ITEM # 2= 2.513
D.F. = 2; PROBABILITY GREATER THAN .25

PERCENTAGE OF STUDENTS FROM EACH STATUS GROUP GIVING CORRECT RESPONSES
FOR ITEM # 2 FOR EACH ABILITY GROUP AS DETERMINED BY TOTAL TEST SCORES

	TOTAL TEST SCORES		
	0- 7	8- 12	13- 32
MALES	12.2	14.4	53.8
FEMALES	10.5	23.0	47.5

	TOTAL TEST SCORES		
	0- 7	8- 12	13- 32
MALES	12.2	14.4	53.8
FEMALES	10.5	23.0	47.5

CAMILLI CHI-SQUARE FULL
CANNOT BE COMPUTED FOR ITEM # 3

SCHEUNEMAN CHI-SQUARE CORRECT
CANNOT BE COMPUTED FOR ITEM # 3